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Volume 2, WELDING FABRICATION PROCEDURE

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RECORD OF REVISIONS

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0	8/16/04	Initial issue.	Kelly Bingham, <i>FWO-DECS</i>	Gurinder Grewal, <i>FWO-DO</i>

Responsible Engineering Standards POC and Committee
for upkeep, interpretation, and variance issues

WFP 2-04	<u>Welding POC/Committee</u>
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WFP 2-04 AWS D1.1, STRUCTURAL WELDING STEEL

1.0 PURPOSE AND SCOPE

- A. This welding procedure governs the welding of components to the requirements of AWS D1.1 (Reference 1). The Code edition and addenda for this procedure shall be the latest in effect or as otherwise specified by engineering requirements.
- B. The use of AWS standard welding procedure specifications shall be in accordance with GWS 1-02, *Administrative Control of Welding*.

2.0 REFERENCES

- 1. AWS D1.1, "Structural Welding Code"

3.0 WELDER QUALIFICATION

- A. Welder/welding operators shall be currently certified, having performed qualification tests in accordance with GWS 1-05, *Welder Performance Qualification & Certification*.

4.0 WELDING PREREQUISITES

- A. All welding shall comply with the requirements specified in the Welding Procedure Specification (WPS) or Welding Technique Sheet (WTS).
- B. Welding shall not be performed when the ambient temperature in the immediate vicinity of the weld is lower than 0° F or when surfaces are wet or exposed to rain, snow, dust, or high wind. The welder and weld joint shall be sufficiently protected from inclement conditions. Care shall be taken to assure that moisture has not been trapped between members that are to be welded and that moisture has not been introduced into previously fit-up joints prior to final welding. Preheating above the minimum specified temperature on the WPS or WTS may be necessary to remove any entrapped moisture. The additional preheat should be applied if there is suspicion of moisture being present.

5.0 MATERIALS

- A. Base Materials
 - 1. Only materials specified in the WPS or WTS may be welded using this procedure.
- B. Filler Materials
 - 1. Welding filler materials to be used with this procedure are specified in the WPS or WTS. A listing of applicable welding filler materials is provided in GWS 1-07, *Material Specifications*.
 - 1. Requirements for the purchase and control of welding filler material shall be in accordance with GWS 1-03, *Welding and Brazing Material Procurement and Control*.
 - 2. Welding filler materials (electrodes, bare filler wire, etc.) must be utilized by welders making weldments with this procedure. Welders shall not perform welds autogenously.

6.0 BASE MATERIAL JOINT PREPARATION

- A. Surfaces and edges to be welded shall be smooth, uniform, and free from fins, tears, cracks, and other discontinuities that would adversely affect the quality or strength of the weld.
- B. Members to be joined may be cut to shape and size by machining, shearing, chipping, grinding, thermal cutting, or air carbon arc gouging.

7.0 BASE MATERIAL JOINT CLEANING

- A. Prior to welding, surfaces for welding shall be clean and free from paint, oil, rust, scale, slag, grease, and other foreign materials that are detrimental to welding.
- B. Solvents approved for use on the base material and weld materials are methyl alcohol, ethyl alcohol, isopropyl alcohol, acetone, methyl ethyl ketone, toluene, Varson 4, Dowanol EB, and Stoddard solvents.

8.0 JOINT FIT-UP AND ALIGNMENT

- A. The root opening and fit-up tolerances shall be as specified in GWS 1-06, *Weld Joint Design*. If the tolerances cannot be achieved, the end preparations may be built up by welding or re-prepared by machining or grinding.
- B. The parts to be joined by a tee or fillet weld shall be brought into as close contact as is practicable. The maximum gap between these parts shall not exceed $\frac{3}{16}$ in. If the separation is greater than $\frac{1}{16}$ in., each leg of the fillet weld shall be increased by the amount of separation.
- C. The gap between faying surfaces of lap joints or butt welds utilizing backing shall not exceed $\frac{1}{16}$ in.
- D. Parts to be joined by butt welding shall be carefully aligned to maintain an offset not exceeding 10 % of the thickness of the thinner part joined, but in no case more than $\frac{1}{8}$ in. shall be permitted as a departure from the theoretical alignment. In correcting misalignment in such cases, the parts shall not be drawn into a slope exceeding $\frac{1}{2}$ in. in each 12 in. of length. Measurement of offset shall be based upon centerline of parts unless otherwise shown on the drawing. The degree of angle on the perpendicular member of the joint shall be as specified in engineering standards/documents or drawings.
- E. The parts to be joined by partial penetration groove welds parallel to the length of the member (bearing joints excepted), shall be brought into as close contact as practicable. The gap between parts shall not exceed $\frac{3}{16}$ in.

9.0 PREHEAT

- A. When the base material temperature is below the minimum preheat temperature specified in the WPS or WTS, the base material shall be heated to the minimum preheat temperature prior to welding.
- B. The preheat temperature shall be maintained for a distance of at least 3 in. or the thickness of the thicker part being joined, on each side of the weld joint and in advance of the welding.

- C. Preheat temperature above 125° F shall be checked by a surface pyrometer, “Tempilstik,” or non-mercury-type thermometer. Temperature indicating crayons shall not be used directly in the weld zone.

10.0 TACK WELDS

- A. Tack welds shall be made by a qualified welder in accordance with an approved WPS or WTS.
- B. Acceptable tack welds may be incorporated into the final weld.
- C. Defective tack welds shall be removed or repaired prior to welding.

11.0 BACKPURGES

Not applicable.

12.0 INTER-PASS TEMPERATURE (IPT)

- A. Inter-pass temperature shall not exceed the maximum value specified in the WPS or WTS and shall be checked on the surface of the component using a surface pyrometer, “Tempilstick,” or non-mercury-type thermometer. Temperature indicating crayons shall not be used directly in the weld zone.
- B. If the temperature of the weld is above the maximum inter-pass temperature specified in the WPS or WTS, the weld shall be allowed to cool to below the maximum inter-pass temperature, but not below the minimum preheat temperature, prior to resumption of welding.

13.0 WELDING TECHNIQUE

- A. Welding voltage and amperage shall be in accordance with the limits specified in the WPS or WTS. Specified voltage ranges are not mandatory for AWS purposes. Voltage and amperage range gages located on the welding power supply are for reference only and are not mandatory check or hold points. Voltage and amp range checks for documentation purposes shall be performed by a qualified (CWI or equivalent) inspector using calibrated voltage and amp meters or approved welding parameter recording equipment.
- B. Cracks or blowholes that appear on the surface of a weld bead shall be removed by filing, grinding, chipping, or air carbon arc gouging before depositing the next bead. Oxygen gouging shall not be used on quenched and tempered steel.
- C. Before welding over previously deposited material, all slag and flux shall be removed, and the weld and adjacent base material within 1” on either side of the weld shall be brushed clean.
- D. For double-welded butt joints, the second side to be welded, shall be prepared by suitable methods such as chipping, grinding, or air carbon arc gouging to sound material before welding.
- E. The minimum size of a root pass shall be sufficient to prevent cracking but not less than 1/8”.
- F. The maximum thickness of root passes in groove welds shall be ¼ in.

- G. The maximum size of single-pass fillet welds and root beads of multiple-pass fillet welds shall be:
- $\frac{3}{8}$ in. for the flat (1F) position
 - $\frac{5}{16}$ in. for the horizontal (2F) and overhead (4F) positions
 - $\frac{1}{2}$ in. for the vertical (3F) position.
- H. The maximum thickness of layers subsequent to root passes of groove and fillet welds shall be:
- $\frac{1}{8}$ in. for the flat (1G & 1F) position
 - $\frac{3}{16}$ in for vertical (3G & 3F), overhead (4G & 4F), and horizontal (2G & 2F) positions.
- I. Peening
1. Peening of Group I materials may be used to control distortion or to relieve residual stresses. Peening shall not be performed until $\frac{3}{8}$ in. of the joint thickness has been deposited. Peening shall not be applied to cover passes, base material, or weld layers requiring nondestructive examination. Peening shall not be used to mask a defect.
- J. Control of Distortion and Shrinkage
1. In assembling and joining parts of a structure or of built-up members and in welding reinforcing parts to members, the procedure and sequence shall only be performed to minimize distortion and shrinkage.
 2. Insofar as practicable, welds shall be deposited in a sequence that will balance the applied heat of welding while the welding progresses.
 3. The welding sequence applied, in conjunction with the WPS or WTS and overall fabrication methods, shall produce members or structures meeting the specified quality requirements.
 4. The direction of the general progression in welding on a member shall be from points where the parts are relatively fixed in position with respect to each other toward points where they have a greater relative freedom of movement.
 5. Joints expected to have significant shrinkage should usually be welded before joints expected to have lesser shrinkage. Such joints should be welded with as little restraint as possible.
 6. In making welds under conditions of severe external shrinkage or restraint, the welding shall be continuous to completion or to a point that will ensure freedom from cracking before the joint is allowed to cool below the minimum-specified preheat temperature.
- K. All welding processes may be single pass or multiple passes per side unless otherwise specified in the WPS or WTS.
- L. Welding shall be performed single arc unless otherwise specified in the WPS or WTS.

14.0 INSPECTOR QUALIFICATION

- A. The Inspector who performs welding inspection for acceptance to this procedure shall be an AWS-CWI, and authorized by the LANL WPA.

15.0 ACCEPTANCE CRITERIA FOR COMPLETED WELDS

A. Butt Welds

1. As-welded surfaces are permitted; however, the surface of welds shall be sufficiently free from coarse ripples, grooves, overlaps, abrupt ridges, and valleys.
2. The surface condition of the finished welds shall be suitable for the proper interpretation of radiographic and other nondestructive examinations when nondestructive examinations are required. In those cases where there is a question regarding the surface condition, the film shall be compared to the actual weld surface for interpretation and determination of acceptability.
3. Undercuts shall not exceed 0.01 in. (0.5 mm) and shall not encroach on the minimum required section thickness for shear moment connections and primary members cyclically loaded in tension. For other than shear moment and primary connections cyclically loaded in tension, undercut shall not exceed $\frac{1}{32}$ in. (0.8 mm) and shall not encroach on the minimum required section thickness.
4. Reinforcement shall not exceed $\frac{1}{8}$ in. in height and shall have gradual transition to the plane of the base material surface.
5. Groove welds shall be terminated at the ends of a joint in a manner that will ensure sound welds. This shall be done by use of extension bars or runoff plates or by grinding starts and stops. After the weld is completed, the extension bars or runoff plates shall be removed and the junction ground flush.

B. Fillet Welds

1. As-welded surfaces are permitted; however, the surface of welds shall be sufficiently free from coarse ripples, grooves, overlaps, abrupt ridges, and valleys.
2. The surface condition of the finished welds shall be suitable for the proper interpretation of nondestructive examinations.
3. Undercuts shall not exceed 0.01 in. (0.5 mm) and shall not encroach on the minimum required section thickness for primary members cyclically loaded in tension. For joints other than cyclically loaded in tension, undercut shall not exceed $\frac{1}{32}$ in. (0.8 mm) and shall not encroach on the minimum required section thickness.
4. Fillet welds may vary from convex to concave. The size of a fillet weld is determined as shown in Attachment 1.
5. Weld beads shall be continuous through high stress areas such as corners.
6. The minimum fillet weld size, except for fillet welds used to reinforce groove welds, shall be in accordance with Attachment 2.
7. The minimum length of an intermittent fillet weld shall be 1 $\frac{1}{2}$ in.
8. The maximum fillet weld size detailed along edges of material shall be in accordance with Attachment 3.

C. Arc Strikes

1. Cracks or blemishes outside of the area of permanent welds resulting from arc strikes shall be ground to a smooth contour and checked to ensure soundness.

16.0 WELD REPAIRS

- A. Weld repairs shall be performed using the original WPS or WTS or an approved repair WTS to restore a weld to an acceptable condition.
- B. The removal of weld material or portions of the base material may be done by machining, grinding, chipping, or air carbon arc gouging. It shall be done in such a manner that the remaining weld material or base material is not nicked or undercut. Oxygen gouging shall not be used in quenched and tempered steel. Unacceptable portions of the weld shall be removed without substantial removal of the base material. Additional weld material to compensate for any deficiency in size shall be deposited using an electrode preferably smaller than that used for making the original weld, and preferably not more than $\frac{5}{32}$ in. in diameter. The surfaces shall be cleaned thoroughly before welding.
- C. The weld shall be corrected as follows:
 - 1. Overlap or Excessive Convexity - Remove excess weld material.
 - 2. Excessive Concavity of Weld or Crater, Undersize Welds, Undercutting - Prepare surfaces and deposit additional weld material using the original Welding Procedure Specification (WPS) or Weld Technique Sheet (WTS).
 - 3. Excessive Weld Porosity, Excessive Slag Inclusions, Incomplete Fusion - Remove unacceptable portions and re-weld.
 - 4. Cracks in Weld or Base Material - Determine the extent of the crack by use of magnetic particle or liquid penetrant (PT) examination. Remove the crack, using the “boat” technique to sound material 2 in. beyond each end of the crack, and re-weld.
- D. The repaired weld shall be reexamined by the method and technique originally used, with the same acceptance criteria.

17.0 POST WELD HEAT TREATMENT

- A. Post weld heat treatment, when indicated in the engineering specification or in the WPS or WTS, shall be performed in accordance with GWS 1-08, *Post Weld Heat Treatment*.

18.0 ATTACHMENT WELDS

- A. Attachment welds shall be performed in accordance with an approved WPS or WTS.
- B. Materials used for welded attachments shall be equal to, or compatible with the base material.
- C. When applying attachments to materials of different thicknesses, the preheat and inter-pass requirements of the thicker material shall be observed.
- D. When the specification requires temporary attachments to be removed, a method of removal that will not damage the base material shall be utilized; i.e., cut, grind, or air carbon arc gouge the attachment off and grind the area flush.

19.0 ATTACHMENTS

Attachment 1: Weld Profiles and Sizes

Attachment 2: Minimum Fillet Weld Size for Pre-qualified Joints

Attachment 3: Maximum Detailed Size of Fillet Weld Along Edges